

SOLAR TOTAL ENERGY PROJECT  
(STEP)

PERFORMANCE ANALYSIS

OF

HIGH TEMPERATURE THERMAL ENERGY STORAGE SUBSYSTEM

D. M. Moore  
Georgia Institute of Technology  
Engineering Experiment Station  
Atlanta, Georgia 30332

The Solar Total Energy Project (STEP) at Shenandoah, Georgia is a cooperative effort between the United States Department of Energy (DOE) and Georgia Power Company to help maximize the potential of solar energy. Sandia National Laboratories provides technical management for the U. S. Department of Energy. The design, operation, and analysis of this point focus system have been supported by a wide range of institutional and industrial organizations. When funded by DOE in 1977 as part of the National Solar Thermal Energy Program, it was the world's largest industrial application of solar cogeneration.

There are 114 twenty-three foot diameter parabolic dishes that track the sun in two axes and provide 11 billion BTUs of energy annually. Heat taken from a heat transfer fluid boils water and superheats steam for a Rankine steam turbine-generator. The design output of the system, under maximum insolation, is 400 kW(e), 1380 pounds per hour of extracted steam for pressing clothes, and 257 tons of air conditioning for cooling the Bleyle garment plant to which the energies are provided.

In 1982 a large number of unexpected electrical and mechanical problems limited experimental operations. However, many lessons were learned from these anomalies that have been totally addressed and resolved. The next generation system should profit greatly by this learning experience. In 1983, system performance tests were initiated, and the thermodynamic design has been validated. Each individual subsystem and component have demonstrated a design basis for future larger systems. A number of prescribed tests associated with this Test Operations Phase have been initiated and will be continued to the middle of 1984. These tests will evaluate total system modes of operation for future commercial type operation.

This technical paper will highlight (1) the 1982 milestones and lessons learned; (2) performance in 1983; (3) a typical day's operation; (4) collector field performance and thermal losses; and (5) formal testing. An initial test that involves characterizing the High Temperature Storage (HTS) Subsystem will be emphasized. The primary element is an 11,000 gallon storage tank that can provide energy to the steam generator during transient solar conditions or can extend operating time. Overnight, thermal losses have been analyzed. The length of time the system can be operated at various levels of cogeneration using stored energy will be reviewed.

### HTS TEST OBJECTIVES

- . Energy Storage Capabilities
- . Thermocline Stability
- . Heat Loss

### HTS TEST # 1

- . Heat Tank to 500°F
- . Establish 500 - 750°F Thermocline
- . Monitor Temperatures Overnight
- . Operate System from Storage - 250 kW

### HTS TEST # 2

- . Heat Tank to 750°F
- . Monitor Temperature Overnight
- . Operate System from Storage - 250 kW

### HTS TEST # 3

- . Heat Tank to 750°F
- . Monitor Temperature Overnight
- . Operate System from Storage - 300 kW

## HTS TEST RESULTS

### Energy Storage Capabilities

	<u>Duration of Test Minutes</u>	<u>Power Level kW</u>	<u>Electricity Produced kWh</u>
Test # 1	.19	250	76
Test # 2	45	250	180
Test # 3	39	300	190

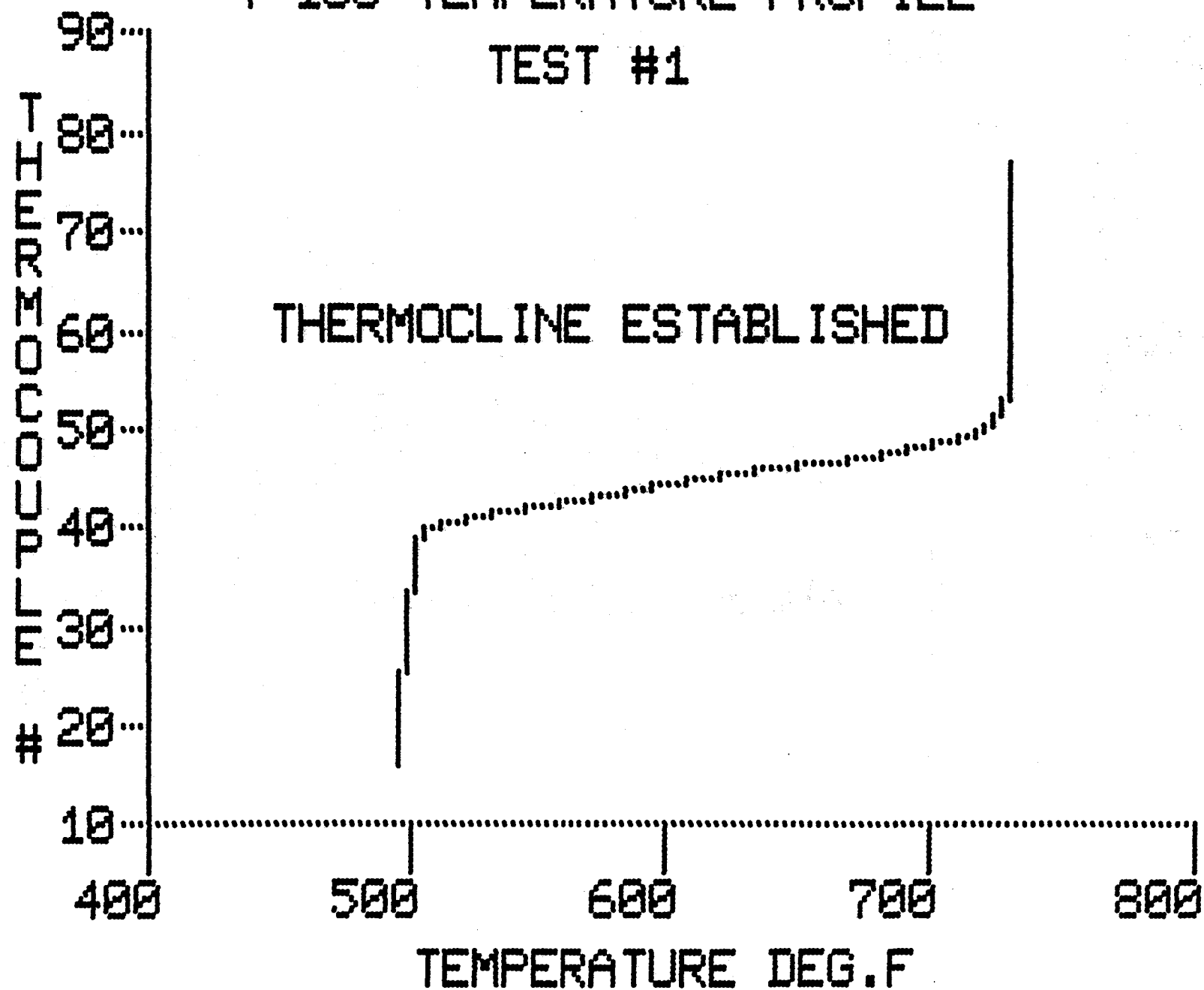
### Storage Efficiency

	<u>Energy Stored BTU x 10<sup>6</sup></u>	<u>Energy Extracted BTU x 10<sup>6</sup></u>	<u>Storage Efficiency %</u>
Test # 1	2.60	1.89	72.7
Test # 2	5.63	4.41	78.3
Test # 3	5.58	4.51	80.8

### Heat Loss Analysis

	<u>Heat Loss 14 Hr. Period BTU</u>	<u>Heat Flux<sub>2</sub> BTU/HR FT<sup>2</sup></u>
Design	168,000	15.6
Test # 2	326,000	30.4
Test # 3	228,000	26.0

# T-103 TEMPERATURE PROFILE TEST #1

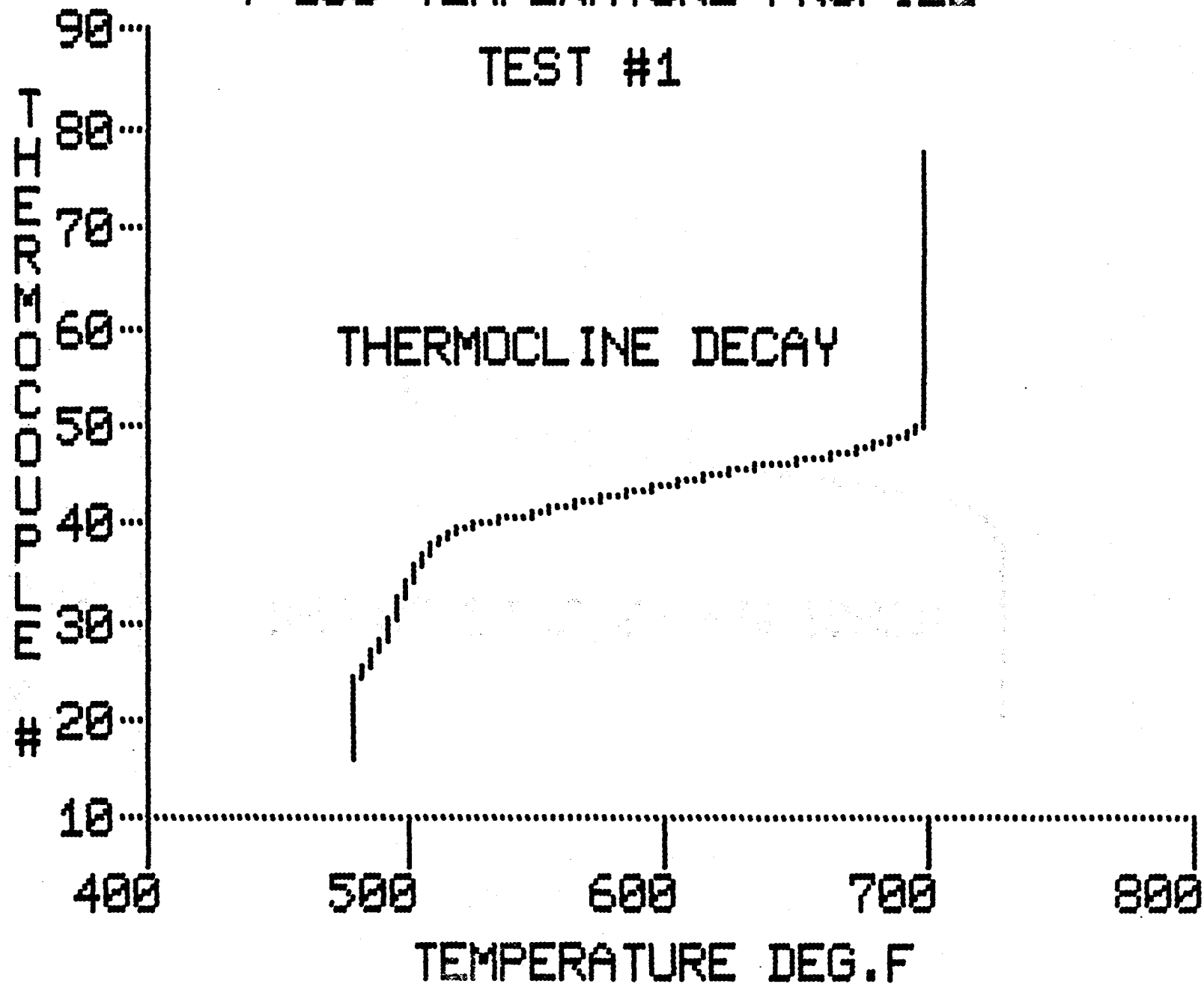


# T-103 TEMPERATURE PROFILE

TEST #1

THERMOCLINE DECAY

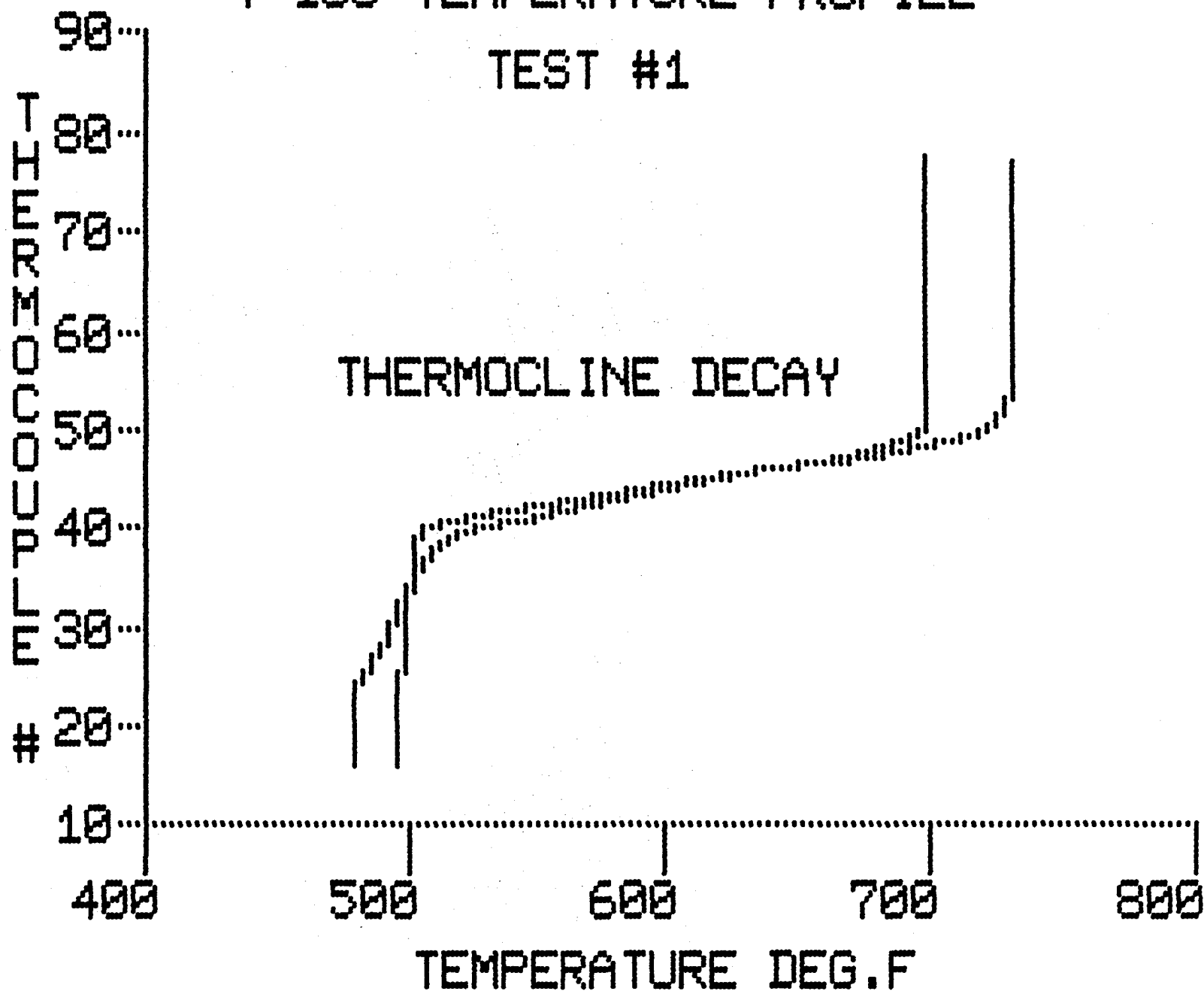
141



# T-103 TEMPERATURE PROFILE

TEST #1

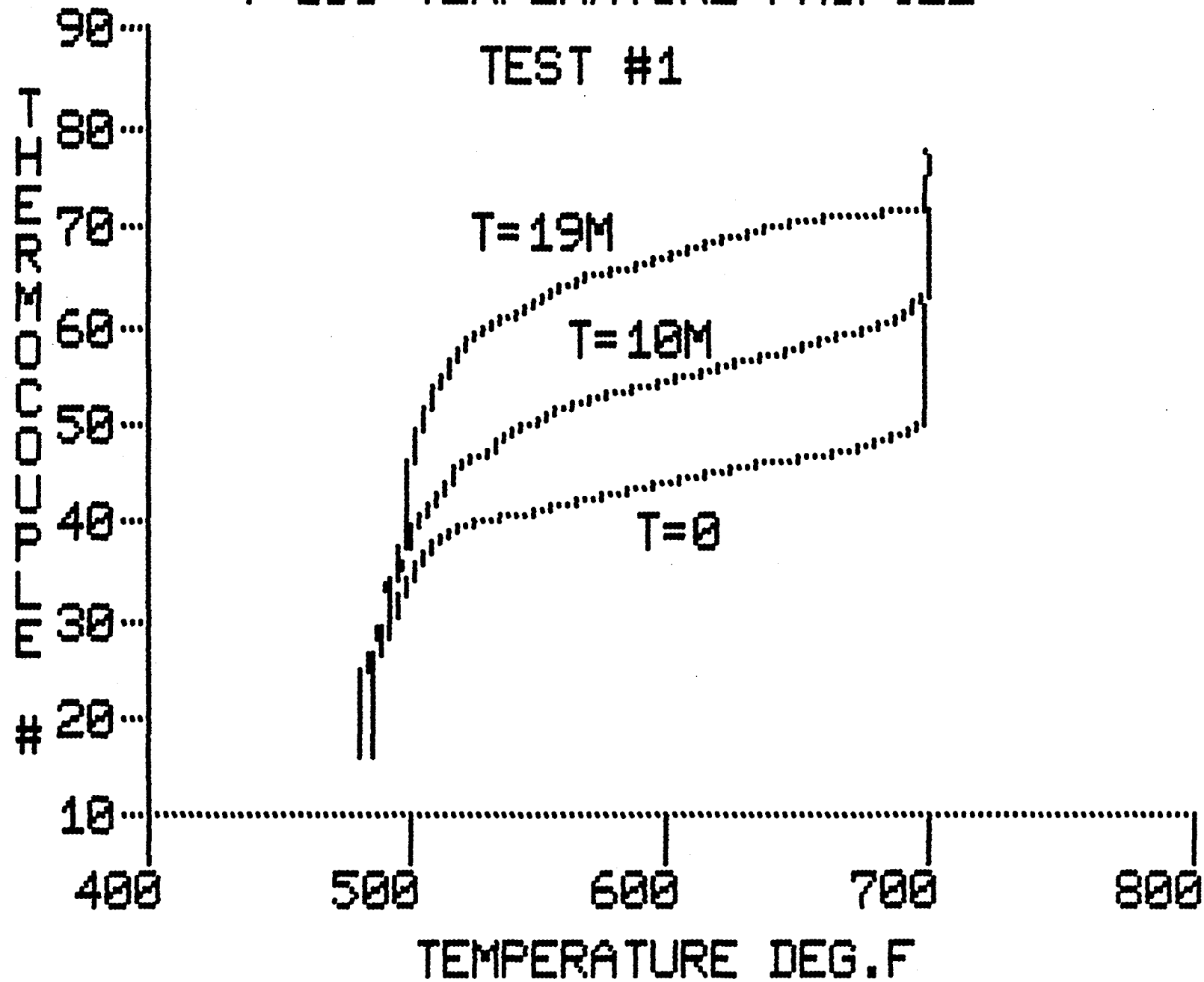
THERMOCLINE DECAY



# T-103 TEMPERATURE PROFILE

## TEST #1

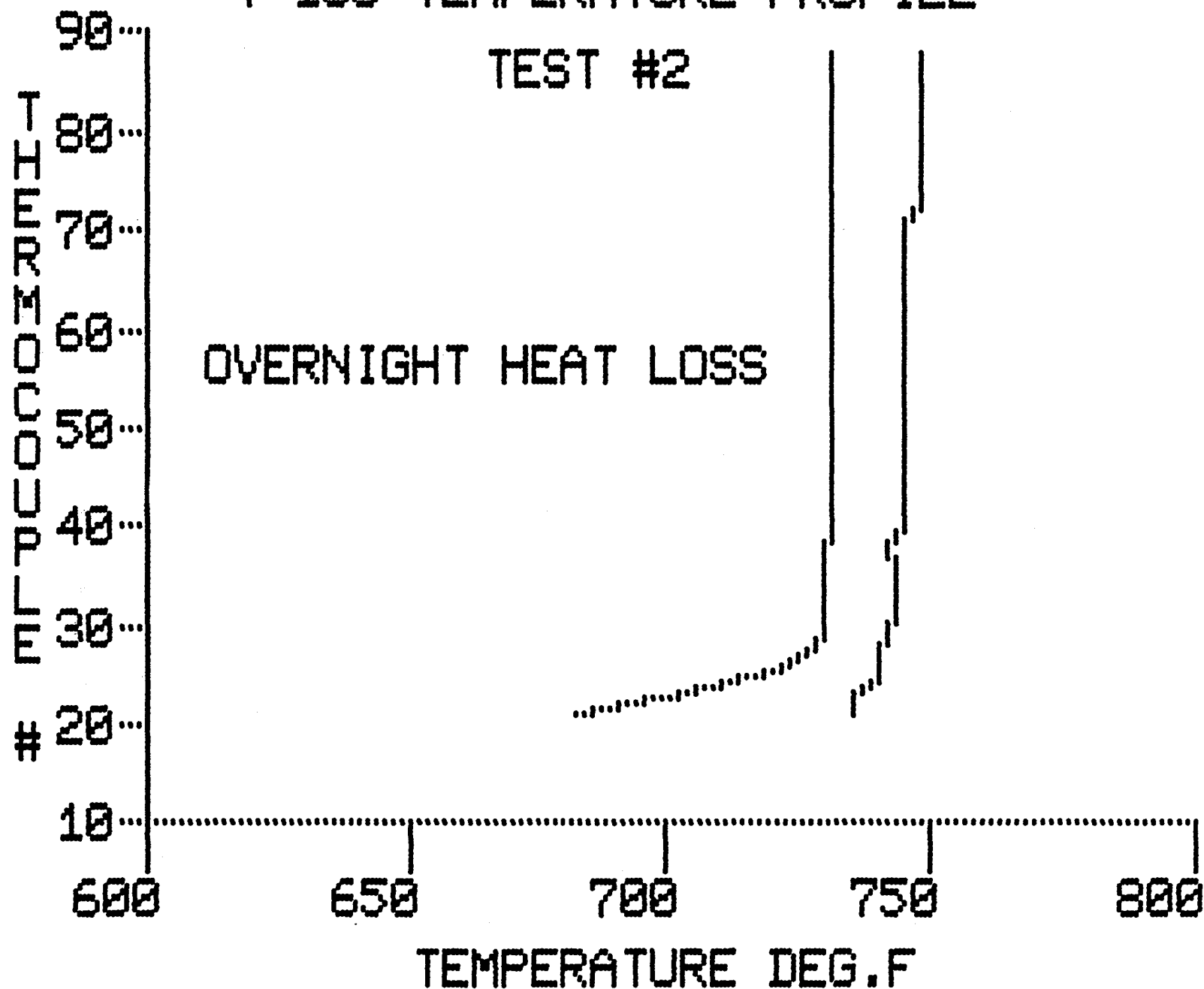
143



# T-103 TEMPERATURE PROFILE

TEST #2

OVERNIGHT HEAT LOSS





# T-103 TEMPERATURE PROFILE

## TEST #2

